tions to dense phases could possibly explain the anomalously low compressibility in the mixed phase region above 14.4 GPa. Other materials such as Al_2O_3 have been observed to display yield behavior similar to quartz, and geologic materials are possible candidates for similar behavior. The question of heterogeneous melting and its effect on subsequent high-pressure loading in quartz is a problem of importance that should be pursued with some urgency.

As the different experimental investigations have been summarized, the role of experimental technique has been found to be significant. Better understanding of the bismuth transition involved the use of projectile impact loading techniques and the use of detectors with capabilities for accurate time-resolved sample response measurements. A similar situation is noted for the iron transition. The combination of projectile impact loading and time-resolved measurements appears to be particularly effective for studying shock-induced phase transitions.

Finally, it is perhaps worthwhile to emphasize again that it is a mistake to overgeneralize concerning any aspect of shock-induced phase transitions in either a positive or negative sense. There are many different situations that must be considered on their own merit. It is clear, however, that shock loading experiments can provide credible data concerning pressure-induced transitions. Nevertheless, technique is still critical and it is relatively easy to make errors of interpretation. Comprehensive investigations in the hands of skilled observers, along with critical interpretations of the data, will undoubtedly yield valuable thermodynamic data on phase transitions which may be uniquely obtained under shock loading or may prove to be valuable supplements to static high-pressure data.

Note added in proof: Several references which were inadvertently omitted or have recently come to our attention are the following:

(1) on shock induced vaporization, the paper by Horung and Michel (1972);

(2) on melting in magnesium under shock loading, the paper by Urtieu and Grover (1977);

(3) additional data on transitions in titanium, zirconium, and hafnium are given in McQueen *et al.* (1970);

(4) a thorough study of phase transitions in shock compressed BN is described in Gust and Young (1977); and

(5) the excellent review of optical properties under shock compression by Kormer (1977) summarizes melting curves for alkali halides, and comments upon optical effects associated with polymorphic phase transitions.

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APPENDIX A

A summary of polymorphic phase transformations is presented in Table A1.

TABLE AI. Summary of shock-induced polymorphic phase transition observations.[a]

Material	Condition	Transition conditions Stress (GPa)	Transition conditions Compression (%)	Technique	Remarks	References
A. Iron and iron alloys						
Iron						
Armco iron	AR	13.6–13.0	6.69–6.37	E-1	7.2–57 mm	Bancroft *et al.* (1956)
Armco iron	Ann	13.2–12.5	6.41–6.18	E-1	25–57 mm, +	Minshall (1961)
Armco iron	AR	12.8	6.41	E-1	25 mm	Minshall (1961)
Armco iron	CR	13.5	6.57	E-1	25 mm	Minshall (1961)
Armco iron	Ann	13.6	6.49	E-1	25 mm, $T_0 = 222$ K	Minshall (1961)
Armco iron	Ann	13.2	6.26	E-1	25 mm, $T_0 = 330$ K	Minshall (1961)
Armco iron	AR	···	···	P-16	Smooth spall	Erkman (1961)
Armco iron	AR	15.0–1.9	···	D-16	24 T_0 values 78–1158 K, apparent triple point	Johnson *et al.* (1962)
Armco iron	AR	14.5–12.5	6.9–6.2	E	Prism sample, optical lever	Peyre *et al.* (1965)
Armco iron	Ann	12.9 ± 0.1	6.4 ± 0.05	E-1	25 mm, ψ	Loree *et al.* (1966a)
Armco iron	AR	···	···	E-13	Wave structure, *	Novikov *et al.* (1965)
Armco iron	···	15.0	···	P-11	4–17 mm, +	Anan'in *et al.* (1973)
Armco iron	···	14.1–13.1	···	P-4	1–25 mm	Forbes *et al.* (1975)
Armco iron	AR	13.7–12.9	6.3	G-9	3–19 mm, +, ψ, ϕ, τ	Barker *et al.* (1974)
Electrolytic iron	AR	···	···	E-15	Shock demagnetization	Royce (1968)
Iron	AR	···	···	E, G-14	Electrical resistance	Wong *et al.* (1968)
Iron	AR	···	···	E-15	Demagnetization eddy currents	Wong (1969)
Iron	···	···	···	E-14	Electrical resistance	Fuller *et al.* (1962)
Iron	AR	···	···	E-14	Electrical resistance, demagnetization eddy currents	Keeler *et al.* (1969)

(*Continued*)

erial	Condition	Transition conditions Stress (GPa)	Compression (%)	Technique	Remarks	References
ued)						
	AR	···	···	P-20	Double shock and rarefaction shock	Balchan (1963)
	Powder/Bakelite mixture	9.4–11	···	E	Shock demagnetization; $\rho_0 = 5.33$ Mg/m^3	Novikov *et al*. (1974
teels						
	Ann	···	···	P-16	Smooth spall for $P > 14.0$ GPa, ASTM grain size 2–3	Banks (1968)
eel	AR	12.9	6.2	E-1	51 mm	Minshall (1961)
eel	Ann	13.7–12.8	6.7–6.2	E-1	27–51 mm	Minshall (1961)
eel	Hot rolled	···	···	E-2	Wedge sample, qualitative	Katz *et al*. (1959)
eel	Ann	13.6	6.6	E-1	27 mm	Minshall (1961)
eel	Ann	14.1	6.7	E-1	27 mm	Minshall (1961)
teel on)	···	15.3	···	P-11	6–20 mm, +	Anan'in *et al*. (1973)
steel on)	AR	16.0	···	P-11	Also unloading	Anan'in *et al*. (1973)
steel on)	RC60-62	16.2	···	P-11	Also unloading	Anan'in *et al*. (1973)
lloys						
Ni	AR	12.0	···	E-1	$\rho_0 = 7.848$ Mg/m^3	Fowler *et al*. (1961)
Ni	AR	11.8	···	E-1	$\rho_0 = 7.855$ Mg/m^3	Fowler *et al*. (1961)
% Ni	1273 K, 1 h	12.1	6.75	E-4	$\rho_0 = 7.892$ Mg/m^3, 6.4 mm	Gust *et al*. (1970)
% Ni	AR	11.0	···	E-1	$\rho_0 = 7.878$ Mg/m^3	Fowler *et al*. (1961)
Ni	AR	10.2	···	E-1	$\rho_0 = 7.910$ Mg/m^3	Fowler *et al*. (1961)
Ni	AR	11.7	···	E-1	···	Fowler *et al*. (1961)
Ni	AR	8.5	4.2	E-1	···	Loree *et al*. (1966a)
Ni	AR	8.0	···	E-1	···	Loree *et al*. (1966a)
Ni	AR	5.5	3.4	E-1	···	Loree *et al*. (1966a)
% Ni	Ann, quench liquid N 168 h	7.0–<1.0	4.1–1.2	G-8, 12	$\rho_0 = 8.032$ Mg/m^3, 7 mm, 9 various T_0 values between 298 and 663 K, γ phase recovered	Rohde (1970)
% Ni	Ann, quench liquid N 168 h	···	···	G-8, 16	Partial transformation at 2.0 GPa	Rohde *et al*. (1968)
m alloys						
r	AR	12.8	···	E-1	$\rho_0 = 7.825$ Mg/m^3	Fowler *et al*. (1961)
Cr	AR	12.6	···	E-1	$\rho_0 = 7.793$ Mg/m^3	Fowler *et al*. (1961)
Cr	AR	12.5	···	E-1	···	Fowler *et al*. (1961)
% Cr	AR	13.3	···	E-1	$\rho_0 = 7.747$ Mg/m^3	Fowler *et al*. (1961)
Cr	AR	14.9	···	E-1	···	Fowler *et al*. (1961)
Cr	AR	18.2	···	E-1	···	Fowler *et al*. (1961)
Cr	1273 K, 1 h, water quench	13.4–13.1	6.40–6.10	E-4	$\rho_0 = 7.757$ Mg/m^3, 6.4 mm	Gust *et al*. (1970)
% Cr	1273 K, 1 h, water quench	15.7–15.4	7.60–7.44	E-4	$\rho_0 = 7.724$ Mg/m^3, 6.4 mm	Gust *et al*. (1970)
% Cr	1273 K, 1 h, water quench	20.7	9.19	E-4	$\rho_0 = 7.644$ Mg/m^3, 6.4 mm	Gust *et al*. (1970)
% Cr	1273 K, 1 h, water quench	23.8–22.3	10.5–9.83	E-4	$\rho_0 = 7.618$ Mg/m^3, 6.4 mm	Gust *et al*. (1970)
se alloys						
Mn	AR	12.4	6.1	E-1	···	Loree *et al*. (1966b)
Mn	AR	11.0	5.3	E-1	···	Loree *et al*. (1966b)
% Mn	AR	8.5	3.8	E-1	···	Loree *et al*. (1966b)
% Mn	AR	5.8–5.3	2.5	E-1	···	Loree *et al*. (1966b)